oxygen) decreases because of the sediment carried by rivers and decomposition of vegetation (Bucler, 1985).

NUTRIENTS AND BIOMASS IN FRESH WATER LAKES

Plant growth, in the form of microscopic algae and rooted aquatic weeds, is generally limited in nature by a lack of nutrients primarily nitrogen and phosphorus. There are about nineteen elements of nutrients essential for growth. The major elements in phytoplankton growth are C, N, P, H, O. Although any of nutrient's elements can limit growth, phosphorus and nitrogen are the ones most likely to be in limited supply in natural waters system. Nitrogen limited system is considered to be a greater problem since the sources of nitrogen are harder to control, becouse some blue green algae are capable of fixing atmospheric nitrogen, which is impossible to control. If the rate of nutrient input exceed the rate of decomposition, it will lead to eutrophication and an increase in biomass growth potential (Henderson-Sellers, 1987).

In temperate countries, the phytoplankton dominate the lakes. But in tropical lakes, the ecology is more likely to be dominated by macrophytes (Henderson-Sellers, 1987). In the tropical countries such as Brazil, the common problem in eutrophic lakes is the excessive growth of water hyacinth (Buchler, 1985).

Advancing eutrophication in countries which have seasonal change is indicated by large growth rate of algae. Algae is the common forms of aquatic plant in the surface of water where light is present in sufficient intensity to allow the algae to carry on the process of photosynthesis. Some species of algae are able to develop in abundance at depth of 10, 20, or more feet below the surface (Palmer, 1980). Phytoplankton blooms can occur in lakes having concentration as low as 0.3 mg/l of nitrate nitrogen and 0.1 mg/l of phosphorus (Palmer, 1980). Blue green algae may form the water blooms during the warm period. Some water blooms release toxic to fish etc., prevent light for photosynthesis and thereby preventing release of oxygen into the water and the O2 depletion through decay or respiration of the blooms may results in changing colour, odour and taste of the water. The most frequent algae encountered in lakes containing organic wastes are blue green algae and the flagellates. From the intensive studies by Serruya the dinoflagellate population is less dangerous to lake equilibrium than its natural competitors, the bue green algae, Mycrocysties (Leventer, 1972). lake Tegel in Berlin demonstrated the occurances of the heavy blooms of blue green algae (Aphanizomenon floc-aquae, Mycrocysties, Gleotrichia) have the ability to fix atmospheric nitrogen. Nitrogen fixation by those algae can introduce substantial amount of nitrogenous compound for other species non nitrogen-fixing blue green algae such as Mycrocystis and Oscilatoria.

FACTORS AFFECTING THE DEGREE OF EUTROPHICATION

Overfertilization of a system is harmful since it will destroy the integrity of the community which generally results in the elimination of many or even all the normal population. As it has been mentioned above, that the commonest limiting nutrients in fresh water bodies is phosphorus (P), followed by nitrogen (N). Phosphorus may be present in sollution, suspension or absorbed onto particulate matter as otrophosphate, condensed phosphate or as organophosphorus compounds, such as protein (Matthews, 1985).

The major sources of phosphates are from point sources particularly sewage effluent containing P derived from human wastes and detergent formulation; agricultural run-off derived from fertilizers use. In USA 60% of phosphate entering US waterways is from municipal waste. In hot climate eutrophic lakes, the level of phosphorus can be correlated with hot weather and high residence time of the water in the lake over rainy period of the year (Buchler, 1985).

a. Detergent Phosphorus Source

The relative contribution sources of P will depend on locality. In a developing country where the use of fertilizer is not as intensive as in developed countries, the input of nutrients from agricultural land may not be very important. In many situation, sewage effluent is a dominant contributor, for instance in UK (Matthews, 1985). In Indonesia, the presence of detergents products have great impact in water quality. Most detergents used in UK are now termed 'soft' or biodegradable and on average about 50% by weigth of detergent is phosphate and during the sewage treatment process a certain percentage of phosphorus is removed.

Detergent is a combination of two main components i.e. surfactant and builder. The application of a builder in a detergent determine the quality, effectiveness, and savety of detergents (Duthie, 1972). To control the phosphate occuring in sewage works in Europe, two substances are used as phosphates substitutes: Zeolite and Nitrilotriacetate (NTA) and Sodium Carbonate in USA. But the substitutions have very undesireable effects (De Jong, 1985) for example phosphate free detergent can affect on washing machines in USA, the cost reason and uncertainty of safety. Because the phosphate plays an essential role in the quality of detegents its replacement is still in question regarding biodegradibility, mobilization of heavy metals and increase in BOD.

The removal of phosphate in sewage effluent is very essential if it is to reach a lake or other water bodies.According to Doemel (1975), the removal of 92-95% phosphorus by advanced treatment greatly rediced the growth potential of algal.

b. Sediment Phosphorus Source

It is difficult to find a simple relationship between nutrient input and eutrophication, because the nutrients are possibly linked with sediments in the catchment areas. The problem of eutrophication can not be rectified by only reducing the external loading to normal level, but also the internal loading from nutrient rich sediment should be taken into account as large concentration of posphate-rich sediment might accumulated over the years. In Lake Erie, Canada 80% of total phosphorus is accumulated in the lake sediment (Williams, 1972). From the samples studies of Gumerman (Kramer,1972) the muds in the lake adsorbed phosphorus rapidly, almost as much phosphorus could be desorbed as sorbed. Factors that determine the adsorption-desorption of phosphorus from sediment appear to be the pH values, calcium concentration, degree of agitation of sediment in water and redox potential. When the redox potential (ratio iron II/iron III) deceases, ferric hydroxides and oxides dissolve and phosphorus released. Hallberg and Schippel in 1972 and 1973 respectively investigated this condition and it was assumed calcium ion. Mortimer experiment (Kramer, 1972) said that as long as O2 concentration at the sediment is greater than 2 mg/l, sediment release of nutrients is nill. Above or below a pH of 5 to 7, phosphorus increase rapidly. And the agitated solution of sediment releases more phosphorus than unstirred solution.

LAHE RESTORATION

a. Indication of Lake Status

Many different techniques can be used for lake restoration. Each method is site spesific, a method may be suitable for a certain lake but not for another the same applies for different countries. In order to find the best approach to restore a lake, it is necessary to know the trophic status of the lake which is based on the concept of nutrient ballance. In order to predict the amount of phosphorus load reduction required, first the concept of trophic categories will be considered. In OECD (Organization for Economics Community Development) study, Vollenweider defines the concept of trophic categories by selecting a number of measurable parameters which were evaluated by taking yearly mean concentration and extreme values for certain parameters. The parameters selected were: total phosphorus, total nitrogen, (it is necessary to measure nitrogen compound as well as phosphorus because nitrogen is the next most frequently limiting nutrients), chlorophyl and transparency (see figure 1,2)

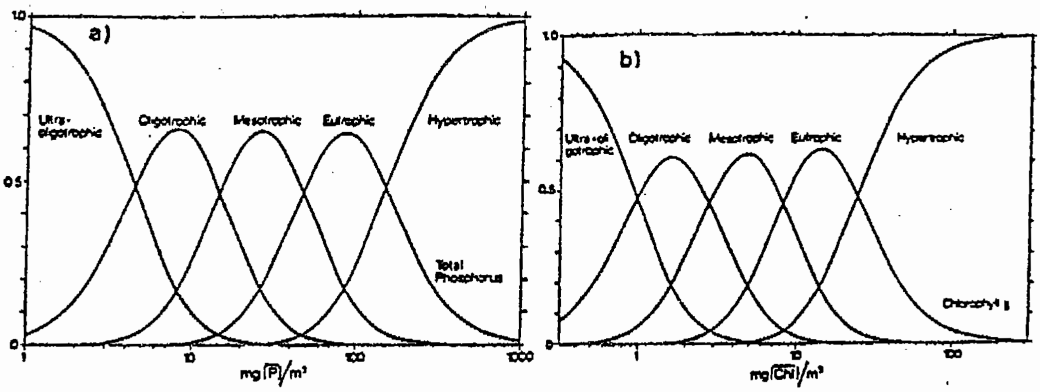

Figure 1. Tropic probability distribution based on a. total phos phorus concentration, b. average chlorophyl concentra tion (Vollenweider, 1985)

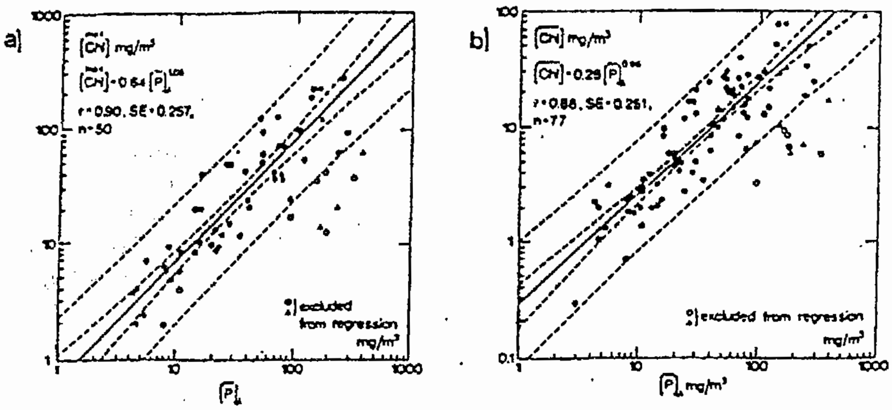

Figure 2. OECD relationship between in-lake phosphorus and a. peak chlorophyl, b. average chlorophyl (Vollenweider, 1985).

The total phosphorus concentration in a lake can be measured by algal assay test (Maloney, 1972). The average chlorophyl concentration can be calculated by using figure 2. The total phosphorus concentration and average chlorophyl concentration identifies the trophic status of the lake in probabilistic sense. Probabilistic considerations are important in managing lakes and are directly pertinent to the question of loading tolerance (Vollenweider, 1985).

b. Detergent Phosphorus Removal

It has been mentioned before that the advanced treatment is the most effectively methods to reduce the phosphorus in sewage effluent. Addition of chemicals to remove phosphorus is relatively simple technique which can achive more than 90% removal efficiency. The alum is added to the influent followed by polimer addition before primary sedimentation tanks. The schematic diagram of the treatment plant is as follow (Williams, 1985).

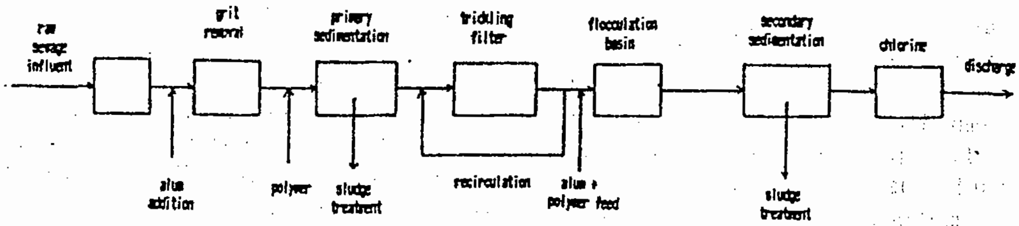

Figure 3. Alum addition in waste water treatment plant (Williams, 1985).

It is suggested to take laboratory test in order to select the optimum dose of alum for use in the plant scale test.

This treatment plant can remove phosphorus to below 1 mg/l limit. The disadvantage of the chemical additions is that it can be expensive due to high cost chemicals and subsequent sludge disposal but it is inexpensive in term of operation.

The principles of phosphorus removal by biological removal (activated sludge plants, see figure 4) are the mechanism of release by bacteria and store the phosphate as a polyphosphates. The bacteria which is reponsible for excess phosphorus removal is acinobacter. Other microorganism have the ability to accumulate polyphosphate.

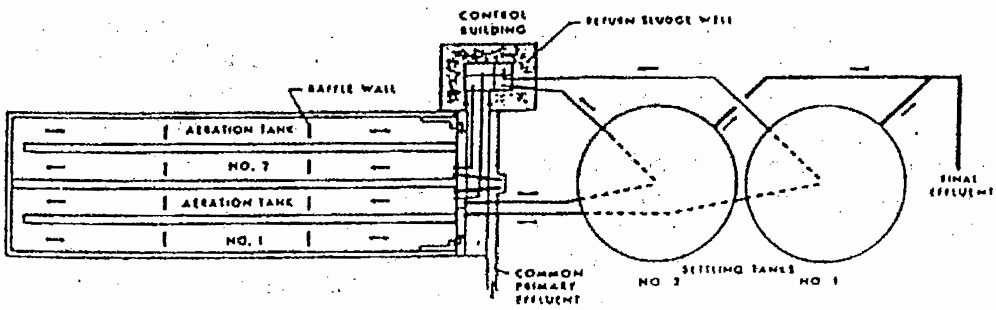

Figure 4. Activated sludge plant (Milbury, 1972)

In order to have maximum phosphorus removal in activated sludge plant specific measure can assist in handling the operating conditions:

1. The preliminary zone has to be anaerobic and must not contain nitrates which can prevent phosphorus release
2. By adding the accetate in the anaerobic zone enhances phosphorus release
3. Proper handling the recycle phosphorus by gravity thickening the underflow of primary settling tank because this sludge contain high volatile fatty acid which can stimulate phosphorus release
4. Operating the aeration tank in a plug flow configuration and maintaining the aeration so that DO is not limiting
5. Operating at a certain level of aeration tank suspended solid (MLSS = mixed liquour suspended solids) and hydraulic retention time of anaerobic zone up to 24 hours compatible with activated sludge removal.

The maximum released of phosphates can be reached at pH 4 and pH 7.5 - 9.6 for phosphorus uptake. At present the temperature on biological phosphorus removal are uncertain (Stephenson, 1985). The advantages of this method is that no chemicals are required and it can be combined with nitrogen removal. One of the major disadvantage is the high degree of skilled operator required and operational problem at very low phosphorus removal and subsequent sludge disposal.

c. Sediment Phosphorus Removal

In lake where the bottom (hypolimnetic) zones almost anoxic, the phosphorus can be released from phosphorus rich sediment. Hypolimnetic aeration has become increasingly important as artificial reaeration induced using hydraulic or pneumatic means (Henderson-Sellers, 1987). The improved dissolved oxygen conditions in

the hypolimnion reduce phosphorus transfer from sediments and maintain a high quality of water. The hypolimnetic aeration also affects the pH which can catalyse phosphorus precipitation. Unfortunately for developing countries this method of eutrophication control is not feasible because of the high capital cost of the aeration system, in addition the effect on the phytoplankton can be different, even in some experiments the algal population increased (Henderson-Sellers, 1987).

Another alternative to remove phosphorus from sediment is by precipitation of phosphate with alumunium. From Jernelov's experiment (Jernelov, 1970) this method of phoshorus reduction can be used in lake. The use of iron Fe^{3+} in precipitation chemical compound is out of question as under anaerobic condition the Fe^{3+} reduces to Fe^{2+} and phosphate released. Alumunium is chosen because it gives better flocculation in this type of water. The best time to add granulated alumunium sulphate in lake Sweden in the early spring as soon as the ice has gone. The result of precipitation with alumunium sulphate in eutrophic shallow lake near Stockholm were the lower concentration of total phosphorus, better oxygen situation during the winter and no total phosphorus, better oxygen situation during the winter and no release of phosphate from sediments although conditions were anaerobic and macrophytes were removed after the precipitation. But again this method has not yet practised in 58 years like the method of algacide addition (copper sulfate) which killed the algae in Fairmont lake, Minnesota. So the further effect on alumunium addition hasn't been monitored for a long time. Such a sustain addition of chemical compound may affects lake water quality, may allowing regeneration of sediment within a certain time, the accumulation of alumunium in the sediment, resistance of plant species to increasingly higher alumunium sulphate dosages (Hanson, 1984). In the Fairmont lake a more complex study of the effects of such chemical compound (e.g. copper sulfate) has come to light because some of th effects are detrimental to lake ecology and may be the most negative effect is the care of too much 'chemical dependancy' (Hanson, 1984).

The other method to remove phosphorus from sediment which may heve no bad effects on aquatic life is to dredge the top metre of sediments itself which is usually rich in nutrients, because they play an important role in the transfer of phosphorus to the water coloumn (Henderson-Sellers, 1987). Although this method is expensive it gives further benefit e.g. the deepening of the lake. Before anr dredging program is done, some action must be taken:

1. Surveying a comprehensive core samples of the sediments in order that the dredging program can be done efficiently and to prevent the accidental exposure of nutrient-rich strata
2. Calculating the rate of sedimentation to asses for how long any dredging programme will be affective.

A hydraulic dredging which acts as vacum cleaner principle can be used if the sediments are uncompacted. The disadvantages of this method are that it has a high water content and it causes disturbances of adjacent sediments. In lake Trummen -Sweden and several of the Fairmont-lakes Minnesota, an addition of alum is undertaken prior to the dredging of sediment. In USA, most sedimentation control and clean up efforts are now centered on the Great Lakes for the cleaning up of contaminated sediment in the bottom of the lake (Engineering News Record, 1990).

Having applied a method of controlling the eutrophication problem, the lake managers can use the LEI (a lake evaluation index) to asses water qualiy changes by monitoring shifts in the index numbers. To determine the LEI, some variables has to be considered: Secchi depth (SD), total phosphorus (TP), total nitrogen (TP), chlorophyl a (CA), disssolved oxygen (DO) and macrophytes (MAC).

The effects of some restoration techniques can not be seen immediately, the time for the lake to respond to the control programmme will depend on the hydraulic residence time (Ryding, 1989), and according to Vollenweider (1985), the reaponse time will equal approximately 3 times the hydraulic residence time. This time lag in response is reflected by the LEI.

CONCLUSION

Eutrophication of lake is a major problem in water quality both in temperate and tropical countries. Its process is irreversible.

Eutrophication is caused by over fertilization of water-body. The nutrients in the form of phosphorus (P) and nitrogen (N) can come from different sources; point source as inflow from sewage, detergent or from internal sources as sediment. Human activities play major role in deteriorating lakes and other surface water bodies. Although detergent is a major source of P, phosphorus-free detergent and its effect is still questionable.

Several method can be done to aleviate eutrophication. As lake eutrophication is site specific, to find the best approach of lake restoration we need to know the trophic condition of the lake. Parameters that can be used to indicate trophic conditions are the total P, N, chlorophyl and the transparency of the water body. However preventiv measure is favourable in term of cost and effectivenes. In implementing a control program to a specific problem, it has to be adjusted to the use of water, and the financial situation of the project.

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